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## ADP012124

TITLE: Flame Spreading and Combustion Behavior of Gun Propellants under High Loading Density Conditions

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TITLE: Army Research Office and Air Force Office of Scientific Research. Contractors' Meeting in Chemical Propulsion [2001] Held in the University of Southern California on June 18-19, 2001

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ADP012092 thru ADP012132

# FLAME SPREADING AND COMBUSTION BEHAVIOR OF GUN PROPELLANTS UNDER HIGH LOADING DENSITY CONDITIONS

(Grant/Contract Number: DAAD 19-01-1-0573)

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## SUMMARY/OVERVIEW:

The ballistic performance of tank gun systems can be increased by using high loading density propellant charges. However, the exact dependency of the muzzle velocity on loading density is not known. Furthermore, there are some uncertainties associated with combustion behavior under extremely high loading density conditions. The burning rate of the propellant and the flame-spreading rate along the propellant charge could be affected by the close proximity of its neighboring propellant grains.

## TECHNICAL DISCUSSION

In the experimental investigation, an extensive database will be developed for studying this gap width effect on the burning rate behavior by using an available doubled-ended windowed strand burner (DEWSB) with detailed diagnostics, including the electro-optical methods for gap distance measurement and close-up photographic recording of the burning surface and combustion event. The propellant regression rate and burning behavior will be characterized as a function of gap space, chamber pressure, and initial temperature. In the theoretical investigation, a comprehensive model will be formulated, numerically solved, and compared with experimental data for model validation. This model will simulate the combustion behavior of two opposing end-burning solid propellant strands with their burning surfaces controlled at a fixed separation distance.

For studying the effect of packing density on flame spreading rate of stick propellants, an existing high-pressure stick propellant bundle combustion test rig will be adopted for measuring the flame spreading rate with an array of fast-response photo-detectors, as well as pressure wave phenomena associated with the flame spreading process. A comprehensive flame-spreading model will also be developed for simulating the flame-spreading phenomenon in tightly packed propellant bundles. This model will be modified from an existing stick-propellant bundle combustion code, developed earlier by Kuo and his co-workers. Both the opposing burning strand model and the flame-spreading model will be compared with experimental data for detailed model validation.

The knowledge to be acquired, and the technique to be developed from this investigation, will be highly beneficial to Army's ballistic and propulsion program. The final output of this research project will be threefold: (1) a detailed characterization of the gap-distance effect on the combustion behavior of gun propellants so that the alteration of propellant regression rate under high loading density conditions can be incorporated into future charge design considerations; (2) the ignition and flame spreading processes over a tightly packed bed of stick propellants will be measured and analyzed for improved understanding of the high loading density effect in order to facilitate future artillery system design; and (3) any engineering correlations to be developed will be very useful for modular integration into the Army's ballistic predictive programs for simulating combustion processes. In addition, this research project will produce more trained engineers to pursue further research in the gun ballistics area.